## REMR Technical Note OM-MS-1.12

# REMR Management System for Lock and Dam Operating Equipment

## Purpose

To provide information about the REMR Management System for lock and dam operating equipment.

## Background

Demand for new construction of civil works projects is frequently overridden by the need to maintain existing projects. Many existing civil works structures are nearing the end of their design service life, yet service to the public must be maintained. Under the REMR Research Program, two series of Management Systems have been developed to focus attention on maintenance and to record and build baseline data to monitor deterioration rates of these structures and their equipment.

## Overview

A REMR Management System has been developed for lock and dam operating equipment. Like previous REMR Management Systems, this one is a collection of standardized condition inspection and rating procedures and personal computer-based database management. The software produces a variety of reports for work planning and budgeting.

## Condition Index Rating

As with other REMR Management Systems, the primary driving element is the condition rating process. The condition ratings follow the standard REMR Condition Index (CI) scale from 0 to 100. As described in REMR Technical Note OM-CI-1.2 (U.S. Army Engineer Waterways Experiment Station 1998), the CI is used to group structures into three zones. The numbers and zones indicate the relative need to perform REMR work because of deterioration of the functional and structural characteristics of the structure. The CI calculation is based primarily on objective field measurements of each piece of equipment's identified distresses (Tables 1 and 2), with some dependence on subjective observations of problems. The CIs for the individual distresses are combined by a weighted average to give the overall condition of the equipment.

**Table 1**
**Assemblies and Associated Distresses**

| Assembly | Associated Distresses |
|---|---|
| Exposed gear assembly | 1,2,3,5,6,7,10,11 |
| Enclosed gear assembly | 1,2,3,5,8,12,13 |
| Gear rack assembly | 1,2,3,5,6,7,14,15,16,17 |
| Strut arm assembly | 1,3,4,18,19 |
| Rocker arm assembly | 1,2,3,4,20,21 |
| Cable assembly | 1,2,4,9,22,23,24,25,26,27,28,29,30,31 |
| Chain assembly | 1,2,3,4,9,32,33,34 |
| Hydraulic cylinder assembly | 1,2,8,35,36,37,38,39 |
| Coupling assembly | 1,3,4,40,41 |

## Functional CI

The functional CI is based on field measurements and observation of defects. It includes both safety and serviceability considerations. These field measurements are related to functional distresses, listed in Table 2. As an example, a tipping of a bushing type gear was detected. A vertical displacement, *X*, of 7.87 mm (0.31 in.) was measured. The limiting value, *Xmax*, of the vertical displacement is 12 mm (0.47 in.) (*X/Xmax* = 1.7 mm (0.67 in.)), which corresponds to a CI of about 54 (see Figure 1). Since 54 is in Zone 2, an economic analysis of all repair alternatives is recommended. A similar procedure is used for the other distresses in Table 2. The CIs for the individual distresses are then combined by a weighted average to give the overall functional condition of the roller dam gate.

## Benefits/Savings

This computerized REMR Management System provides procedures for performing condition surveys, consistent and quantitative condition assessment, and database management. Combined with economic analyses, these procedures allow efficient maintenance and repair (M&R) budget planning through the evaluation of current conditions. The ultimate goal is to achieve the best possible condition for lock and dam operating equipment at any funding level.

**Table 2**
**Distress Descriptions**

| No. | Distress | Brief Description |
|---|---|---|
| 1 | Noise, jump, vibration | Abnormal noise, jumping, or vibration during operation |
| 2 | Anchorage movement, deterioration | Movement of embedded anchorage system and damaged components |
| 3 | Cracks | Breaks in the steel components |
| 4 | Corrosion | Loss of steel due to interaction with the environment |
| 5 | Damaged teeth | Chipped, deformed, pitted, gouged, or corroded teeth |
| 6 | Reduced tooth contact | Improper engagement of the teeth |
| 7 | Tooth wear | Wearing of the gear teeth |
| 8 | Oil leakage | Leakage of oil |
| 9 | Gate or valve connection movement | Relative movement at the connection between the cable and the lifting bracket |
| 10 | Bearing/bushing wear | Excessive play in the exposed reduction gear bearing or bushing |
| 11 | Roller support wear/damage | Freezing or wear of the roller bearing or bushing |
| 12 | Temperature rise of gear box | Temperature change in the gear box oil |
| 13 | Oil contamination | Contamination of oil |
| 14 | Rack attachment deterioration | Deterioration of bolts that anchor the rack to the gate |
| 15 | Reaction roller wear/damage | Wear and freezing of reaction roller bearings and bushings |
| 16 | Gear/rack displacement | Relative displacement between the gear and rack perpendicular to the rack |
| 17 | Rack wear | Edge and bottom wear of the rack |
| 18 | Strut connection movement | Displacement between pin and bushing |
| 19 | Compression spring movement | Abnormal functioning of the compression spring |
| 20 | Rocker and connection rod connection movement | Movement between the rocker arm and the connecting rod |
| 21 | Pivot point pin movement | Movement between the rocker arm and the pivot point anchorage system |
| 22 | Outer wire wear | Reduction in the diameter of the cable wires |

***(Continued)***

**Table 2 (Concluded)**

| No. | Distress | Brief Description |
|---|---|---|
| 23 | Reduction in rope diameter | A reduced rope diameter |
| 24 | Bird cages, kinks, and protruding core | Deformation of the rope by either bird cages, kinks in the rope, or a core that is protruding from the rope |
| 25 | Unlaid strands | Cable strands that are unlaid |
| 26 | Wire breakage | The number of broken wires in any one cable lay |
| 27 | Unequal tension | Improper cable tension |
| 28 | Drum wear | Wear on cable guides and drum groove |
| 29 | Sheave wear | Wear on the sheave groove |
| 30 | Sheave bearing/bushing wear | Excessive play in the sheave bearing or bushing |
| 31 | Idler/roller wear | Improper operation of idlers and rollers |
| 32 | Linkage wear/elongation | Wear and elongation of the chain links, pins, and bearings |
| 33 | Frozen links | Links will not rotate or displace relative to each other |
| 34 | Sprocket wear | Wear of the sprocket |
| 35 | Rod end connection movement | Relative movement between the hydraulic rod and strut |
| 36 | Corrosion/pitting of rod | Corrosion and possibly pitting of hydraulic rod due to interaction with the environment |
| 37 | Damage of rod | Scoring, nicking, or other damage on the rod |
| 38 | Drift | Movement of hydraulic rod with respect to the cylinder with load |
| 39 | Damaged guide | Corrosion and/or attachment movement of the guides |
| 40 | Input shaft and hub movement | Relative movement between the input shaft and the hub |
| 41 | Output shaft and hub movement | Relative movement between the output shaft and the hub |

The collection of consistent, uniform condition assessment data will allow the generation of typical curves reflecting rates of deterioration. The combination of historical condition data and expert opinion should allow prediction of changes in the CI based on maintenance history, operating conditions, and applied M&R policies.

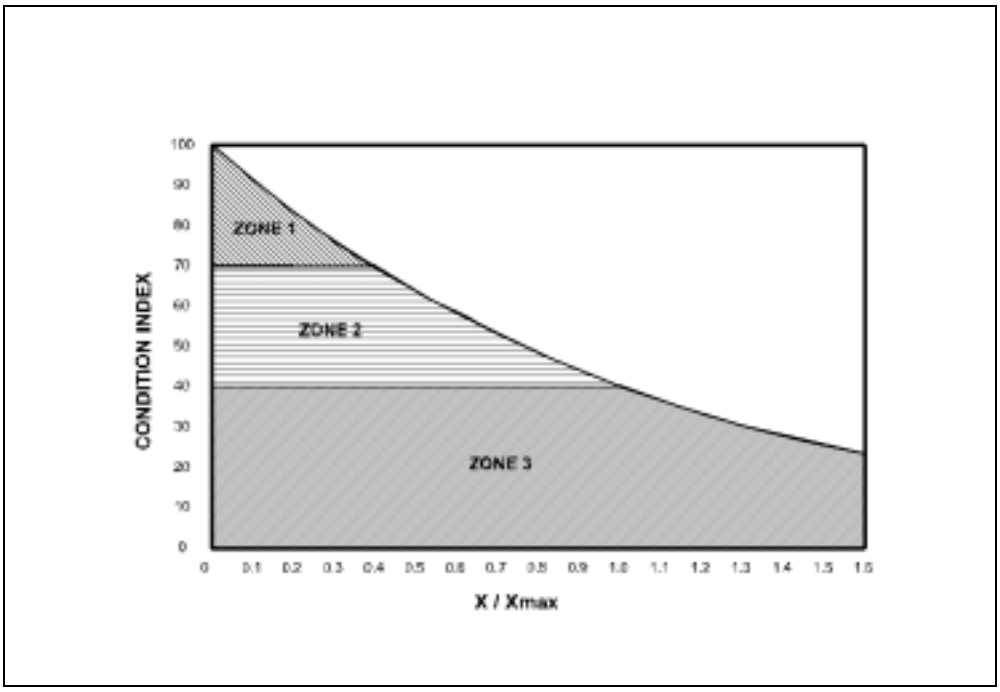


Figure 1. Condition index related to *X/Xmax*

## Status

A technical report, REMR-OM-19 (Greimann et al. 1996), has been published to document the procedures used. Software for operating equipment was completed for some components in Fiscal Year 1997 (FY97) and for the remaining in FY98. The most current REMR software is available on the Internet at **http://www.cecer.army.mil/fl/remr/remr.html**.

## References

Greimann, L., Stecker, J., Mellema, S., Rens, K., and Foltz, S. (1996). "Condition rating procedures for lock and dam operating equipment," Technical Report REMR-OM-19, U.S. Army Construction Engineering Research Laboratory, Champaign, IL.

U.S. Army Engineer Waterways Experiment Station. (1998). "The REMR condition index: Condition assessment for maintenance management of civil works facilities," Technical Note OM-CI-1.2, *The REMR Notebook*. Vicksburg, MS.